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A Comprehensive Study on Energy Efficient Routing Protocol Techniques with Data Aggregation for WSN's

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Abstract: Now a day's wireless sensor networks (WSNs) attract the researchers more due to their popular applications in environment monitoring, radiation and nuclear-threat detection structure; weapon sensors for ships; battlefield reconnaissance and surveillance; military power, control, intelligence, communications and targeting systems and biomedical aspects. Wireless sensor networks can provide low cost solution to various real-world problems. Sensors are low cost devices with limited storage, computational power. Any security mechanism for sensor network must be energy efficient as security is the major concerned when they will be used in large scale as sensors have limited power and computational capability and should not be computational intensive. Here we study the energy-efficient secure routing protocol for wireless networks based on data aggregation we observed in our study following energy-efficient techniques which are Designated path (DP) Scheme, TDMA as the MAC layer Protocols, EF-Tree (Earliest-First Tree) and SID (Source-Initiated Dissemination) According to Fuzzy Variables, Energy Efficient Clustering Protocol (Fz-Leach), OEERP (Optimized Energy Efficient Routing Protocol), It is a cluster based protocol and Enhanced Heterogeneous LEACH (EHE-LEACH) Protocol for Lifetime Enhancement of SNs. Although Sensors don't participate in the routing scheme their energy is conserved at each sensor node.

Key Words: Wireless Sensor Networks (WSNs), Low-Energy Adaptive Clustering Hierarchy (LEACH) & Secure Positioning for Sensor Networks (SPIN).

I. INTRODUCTION

Wireless Sensor Networks have emerged as an significant new area in wireless technology. In the upcoming era, the wireless sensor networks are expected to consist of many of inexpensive nodes, each having sensing capability with partial computational and communication power [1] , [2] and [3] which allow us to deploy a large-scale sensor network.

A wireless network consisting of devices which monitor physical and environmental conditions such as temperature, pressure, motion or pollutants etc. in various areas. Such sensor network are expected to be widely deployed in a large variety of environments for commercial, civil, and military uses such as surveillance, vehicle tracking, climate and habitat monitoring, intelligence, medical, and acoustic data gathering. The confines of wireless sensor networks are the security, power and processing. These limitations and the specific architecture of sensor nodes call for energy efficient and secure communication protocols. The achievability of these inexpensive sensor network is accelerated by the advance in MEMS (Micro Electromechanical Systems) technology, combined with low power, inexpensive digital signal processors (DSPs) and radio frequency (RF) circuits. They consists of a radio transceiver, microcontroller, power supply, and the wireless sensor. The sensing circuitry measures relevant condition related to the environment surrounding the sensor and transforms them into an electric signal. Processing such a signal reveal some properties about objects located and/or events happening in the vicinity of the sensor. The sensor transmits such collected data, usually via radio transmitter, to sink either directly or through a gateway).

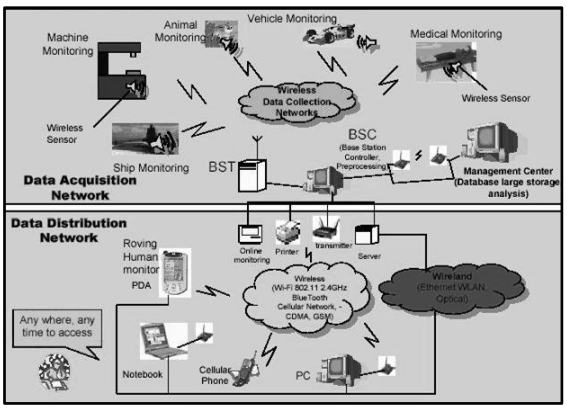

Fig 1- Wireless Sensor Networks

Usually sensor nodes are spatially distributed throughout the session which has to be monitored; they self-organize in to a network through wireless communication, and cooperate with each other with each other to accomplish the common task. Basic

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features of sensor networks are self-organizing capability, dynamic network topology, incomplete power, node failures, short-range broadcast communication and multi-hop routing, and large scale of deployment [5].

The potential of wireless sensor network lies in their flexibility and scalability. The capability of self-organize and wireless communication made them to be more useful in an ad-hoc fashion in remote or risky location without the need of any existing communications. In the course of multi-hop communication, a sensor node can communicate a remote node in the network. These allow the adding of sensor nodes in the network to make bigger the monitored area and hence prove its scalability and flexibility assets. The main challenge in sensor networks is to maximize the lifetime of sensor nodes due because it is not feasible to replace the batteries of several sensor nodes therefore nodes and communication protocols must be made as energy proficient as possible. Among these protocols data transmission protocols have very importance in terms of energy since the energy required for data transmission takes seventy percent of the total energy consumption of a WSN [2]. Area covering and data aggregation [6] techniques can greatly help conserve the inadequate energy resources by eliminating data redundancy and minimizing the number of data transmissions. Therefore, data aggregation methods in sensor networks are widely investigated in the literature [6], [7], [8] and [9].

Security in data communication is another significant issue to be considered while designing wireless sensor networks, as wireless sensor networks may be deployed in hostile areas such as battlefields [2], [10] and [11]. Therefore, data aggregation protocols should work with the data security protocol, as any clash between these protocols might create loopholes in network security.

Presently there are various types of commercially available sensor nodes. University of California at Berkeley has developed Mica mote which is a special purpose sensor node. Other special purpose sensor nodes available are Spec, Rene, Mica 2, Telos etc. Some high bandwidth sensor nodes available are BT Node, Imote 1.0, Stargate, Inryonc Cerfeube etc. [12]. Wireless sensor networks are potentially one of the most significant technologies of this era. Current progress in wireless communications and electronics has enabled the growth of low-cost, low power, multifunctional miniature devices for use in remote sensing applications. The arrangement of these factors has enhanced the sensibleness of utilizing a sensor network consisting of a large number of elegant sensor, enable the compilation, processing analysis and dissemination of important information gathered in types of environments. A sensor network is self-possessed of a large number of nodes of sensor, which consist of sense, information processing and communication ability. Sensor network protocols and algorithms must possess self-organizing abilities. Another unique characteristic of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fit with an onboard CPU. Rather than sending the raw information to the nodes responsible for the synthesis, they use their processing abilities to locally carry out simple computation and transmit only the required and partially processed data. Sensor networks are mainly data-centric rather than address-centric so sensed data are directed to an area containing a cluster of sensors than particular sensor addresses. The similarity in the data obtained by sensors in a dense cluster, aggregation of the data is performed. That is, an aggregator node inside the group, thus falling the communication bandwidth requirements, prepares a summary or analysis of the local data. Aggregation of data increases the level of accuracy and reduces information redundancy. A system order and clustering of sensor nodes allows for network scalability, toughness, capable resource utilization and lower power consumption. The essential objectives for sensor networks are reliability, precision, flexibility, cost effectiveness and ease operation.

II. SYSTEM MODEL

The performance of a safe routing protocol [12] is closely depended on the architectural model and design of the wireless sensor networks, base on the application necessities various architectures and design goals have been considered for sensor networks to capture architectural issues and highlight their implications describe basic configuration of a simple sensor node that depends on the application requirement.

Node Capability: Depending on the kind of work a node can be dedicated to a particular special function such as relaying, sense and integration as engaging the three functionalities at the same time on a node may quickly drain the energy of that node. Inclusion of heterogeneous set of sensors raises multiple issues making data routing more demanding.

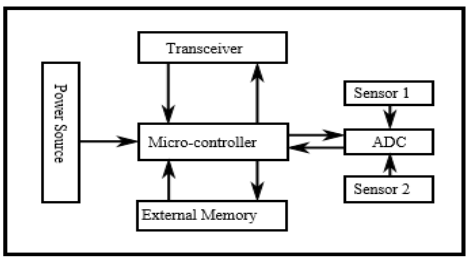

Fig. 2 The typical architecture of the sensor node.

Delivery Model: Based on application requirement of the sensor network, the information delivery model to the sink can be continuous or event-driven or query-motivated and mixture. In the continuous delivery representation, every sensor sends data occasionally. In incident-driven and uncertainty driven models, the transmission of data is triggered when an event occurs or a query is generated by the

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sink. Some networks apply a hybrid model using a combination of continuous, event- driven and query-driven data delivery.

Data Aggregation: In the wireless sensor network, sensor nodes might generate redundant data; similar packets from multiple nodes can be aggregated so that the number of transmissions would be concentrated. Data aggregation is the blend of data from various sources by using functions such as suppression (eliminating duplicates), minimum, maximum and average some of these functions can be performed by the aggregator sensor node, by allowing sensor nodes to conduct in-network data reduction. Recognizing that computation would be low energy consuming than communication, considerable energy savings can be obtained through data aggregation.

Energy Consideration: Energy is very significant parameter during the creation of an communications, and the procedure of selecting the route for broadcast. Since the transmission, power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multihop routing will consume less energy rather than direct communication. However, multihop routing introduces significant overhead for topology management and medium access control. Direct routing would perform good enough if all the nodes were very near to the sink.

Applications of Sensors:

Fig. 2 shows the major roles of WSNs in various applications.

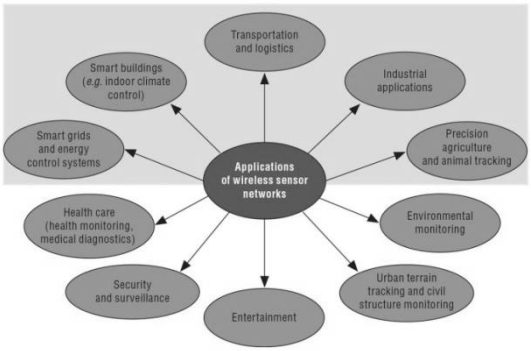

Fig 3- Applications of Wireless Sensor Networks

III. RELATED WORK

In this section different energy efficient routing protocols will be discussed which are LEACH, TEEN and PEGASIS etc.

LEACH:

W. R. Heinzelman et al [5-6] suggested low energy adaptive clustering hierarchy (LEACH) and centralized LEACH protocol for the data communication from source nodes to the BS through gateways, usually known as cluster heads (CHs). LEACH protocol performs the grouping of nodes in to clusters, here local interactions among the cluster members (CMs) is controlled by CH. In addition to this CH have more than a few responsibilities like local data reception, aggregation and fusion, this process controlled the energy of sensor nodes and effectively prolong the lifetime of network field. CHs are most relying sensor nodes as these are taking the responsibility of data transmission to the BS, consume more energy. Therefore the role of CH is dynamically changed such that the high-energy utilization in data transmission to the BS is distributed to all the sensor nodes in the system. LEACH-C used centralized approach and considers the remaining energy. The operation of LEACH and LEACH-C is controlled by rounds, which consist of two phase setup phase and steady state phase. CHs are selected in setup phase and allocate the TDMA schedule to the respective CMs. While in the steady state phase, data communication between the CMs and the CH is performed. A CM in a cluster is active only during its allocated time slot, while CHs are active all the time in steady state phase. LEACH performs periodic CH selection, the energy utilization burden of the CHs is also shared. The duration of the steady state phase is longer than the duration of the setup phase. Study shows that LEACH provides a factor of 4–8 reduction in energy consumption compared to a flat-architecture routing protocol. Major disadvantage of this protocol is that they do not consider the residual energy of sensor nodes and assume zero energy consumption for the formation of cluster.

PEGASIS:

S. Lindsey et al [7-8] suggested power efficient gathering in sensor information systems (PEGASIS) for the data communication from source node to the BS. This protocol is based on the chain, CH is selected randomly from the dedicated chain and accountable for data transmission to the BS. Major disadvantage of this algorithm is that it needs the global knowledge of the network, based on which chain can be constructed using greedy algorithm. There is a proper load matching as a sensor node receive the data from its neighbour, available in the chain, aggregate the same with own data and send to the another neighbour which is the part of chain. Chain will be reconstructed when a node die, now it exclude the die node. Study shows that PEGASIS provides 100–300% lifetime enhancement over LEACH. Another disadvantage of PEGASIS is the significant delay, since the data have to be sequentially transmitted in the chain and the CH waits until all the messages are received before transmitting to the BS.

TEEN:

A. Manjeshwar et al [9-10] suggested threshold sensitive energy efficient sensor network (TEEN) and adaptive threshold-sensitive energy proficient sensor network (APTEEN) to provide event based data transmission. Two types of thresholds are used in TEEN hard threshold (HT) and soft threshold (ST). Here sensor nodes are programmed in such a

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way that it will react to sensed-attribute changes, by comparing the measured value to the HT, if HT exceeded, the sensor node sends it observes data to the CH. ST is used to reduce the redundancy in the transmission. Whenever the HT exceeded, the sensor node also checks the ST for resultant observations. Sensor node does not transmit this information, if the difference between consecutive observations does not exceed the ST. Major drawback of LEACH and PEGASIS is that these protocols periodically transmit the sensed information, and are not suitable for the event based data transmission. TEEN is designed to work effectively only for event based data transmission. APTEEN is the enhancement in TEEN and support for the responding periodically. APTEEN provides a TDMA-based structure for the transmission of sensed information to the cluster and each sensor node transmits its information periodically to the respective CH. However major drawback of TEEN and APTEEN, there is some situation where data is not transmitted.

As WSNs have been used in wide areas of applications, so routing is significant and need a special attention. Lot of research proposals have been reported in the literature addressing this issue. In this section we cover some existing protocols for the issue we have discussed earlier.

Smaragdakis et al. [11] developed stable election protocol (SEP) for the two level heterogeneous networks, which includes two kinds of nodes, normal and advanced nodes. In SEP election probabilities are weighted by the initial energy of a node relative to that of other nodes in the network.

IV. LITERATURE SURVEY

In 2009 Bista, R.; Yong-ki Kim; Jae-Woo Chang, [11] worked on "A New Approach for Energy-Balanced Data Aggregation in Wireless Sensor Networks,". A WSN is self-possessed of a large amount of sensor nodes, which are resource constraints, like limited power. This drives research on how to design routing [11] protocols to get together data efficiently so that the life of the network can be expanded. A usual concept to collect data by a sink node is to transmit data from sensor nodes to the sink node by multi-hop. It raised two problems first is the hotspot difficulty, in which the sensor nodes closer to the sink run out of energy nearer than other nodes. As the result, the network lost its service ability, despite of a large amount of residual energy of the other nodes. The next one is that the system generates needless traffic during data transmission for choosing a proper data-sending path. To resolves the problems, authors, propose a new energy balanced and efficient data aggregation scheme for WSNs, called designated path (DP) scheme.

In 2010 Yanwei Wu; Xiang-yang Li; Mo Li; Wei Lou, [12] proposed "An Energy-Efficient Wake-Up Scheduling for Data Collection and Aggregation". A sensor in wireless sensor networks periodically produces data as it monitors its area. The fundamental operation in such a network is the systematic gathering (with or without in-network aggregation) and transmitting of sensed data to a base station for further processing. A key major challenge in WSNs is to schedule nodes' activities to reduce energy consumption. This research work focused on designing energy-efficient protocols for low-data-rate WSNs, where sensors consume various energy in various radio states (receiving, transmitting, sleeping, listening, and keep idle) and consume energy for state transition. With the use of TDMA as the MAC layer protocol and schedule the sensor nodes with consecutive time slots at various radio states while reducing the number of state transitions.

In 2010 Arabi, Z.,[13] proposed "HERF: A hybrid energy efficient routing using a fuzzy method in Wireless Sensor Networks". This research work focused on Data dissemination is an significant task performed by WSNs. The algorithms of this system depend on a number of factors such as application areas, practice condition, power, and aggregation factors. With respect to these parameters, various algorithms are recommended. An algorithm for hybrid energy efficient routing in wireless sensor networks, which used two algorithms, i.e. EF-Tree (Earliest-First Tree) and SID (Source-Initiated Dissemination) to disseminate data, and employs a fuzzy method to choose group head, and to toggle between two methods, SID and EF-Tree.

In 2011 Katiyar, V.; Chand, N.; Gautam, G.C.; Kumar, A., [14] worked on "Improvement in LEACH protocol for large-scale WSNs". The LEACH protocol is a hierarchical clustering protocol that provides an elegant solution for such protocols. One deficit that affects the presentation of the procedure is endurance of very large and very small clusters in the network at the similar time. This leads to reduce in life span of WSNs. This research work focused to analyze a new energy proficient clustering protocol (FZ-LEACH) that eliminates the above problem by forming Far-Zone. It is a group of sensor nodes, which are placed at locations where their energies are less than a threshold. The results and study show that planned FZ-LEACH algorithm outperforms LEACH in terms of energy consumption and network existence.

In 2012 Chand, K. K.; Bharati, P.V.; Ramanjaneyulu, B.S., [15] investigated "Optimized Energy Efficient Routing Protocol for lifetime improvement in Wireless Sensor Networks". This research work presents a new routing protocol named Optimized Energy Efficient Routing Protocol (OEERP) that improve the lifetime of WSN. It is a cluster based protocol in which the node that acts as cluster-head is changed in each time period. This way enhances the lifetime of the WSN for two reasons primarily. The first cause is the consistent battery drain of the nodes and the second reason is that no node depends on beacon-based transmissions for long time to reach the contact point. Data sensing and

performing data aggregation are also carried out in such a way to reduce the number of transmitted messages to the entrance point. This procedure can be use for any sporadic monitoring application using WSN.

In 2013 Tyagi, S.; Gupta, S.K.; Tanwar, S.; Kumar, N.,[16] researched on "EHE-LEACH: Enhanced heterogeneous LEACH protocol for lifetime enhancement of WSNs". They, focused an Enhanced Heterogeneous LEACH (EHE-LEACH) Protocol for Lifetime Enhancement of Sensor Networks. A preset distance based threshold is used for the bifurcation of direct communication and cluster based communication in the planned scheme. WSNs near to the BS be in touch straight and those which are distant from the Base use group based communication. To assess the act of the proposed system two key parameters known as: Half Nodes Alive (HNA) and Last Node Alive (LNA) are selected. By selecting the distance based threshold with the ratio of 1:9 between direct communication and cluster based communication it has been observed that EHE-LEACH has better network lifetime with respect to various parameters in comparison to the other well known proposals such as LEACH and SEP.

Table 1: Summary of Literature Review

Year	Author	Title	Approach	Result
2009	Bista, R.; Yong-ki Kim; Jae-Woo Chang	A New Approach for Energy-Balanced Data Aggregation in Wireless Sensor Networks	Designated path (DP) Scheme	DP scheme is more energy efficient than the existing schemes directed diffusion (DD) and hierarchical data aggregation (HDA).
2010	Yanwei Wu; Xiang-yang Li; Mo Li; Wei Lou	Energy-Efficient Wake-Up Scheduling for Data Collection and Aggregation	TDMA as the MAC layer Protocols	Reducing the Number of state Transitions.
2010	Arabi, Z	HERF: A hybrid energy efficient routing using a fuzzy method in Wireless Sensor Networks	EF-Tree (Earliest-First Tree) and SID (Source-Initiated Dissemination) According to Fuzzy Variables	HERF has improved energy efficiency.
2011	Katiyar, V.; Chand, N.; Gautam, G.C.; Kumar	Improvement in LEACH protocol for large-scale wireless sensor networks	Energy Efficient Clustering Protocol (Fz-Leach)	FZ-LEACH algorithm outperforms LEACH in terms of energy consumption
2012	Chand, K. K.; Bharati, P.V.; Ramanjaneyulu, B.S.	Optimized Energy Efficient Routing Protocol for life-time improvement in Wireless Sensor Networks	OEERP (Optimized Energy Efficient Routing Protocol), It is a cluster based protocol.	Improves the life time of Wireless Sensor Network (WSN).
2013	Tyagi, S.; Gupta, S.K.; Tanwar, S.; Kumar, N.	EHE-LEACH: Enhanced heterogeneous LEACH protocol for lifetime enhancement of wireless SNs	Enhanced Heterogeneous LEACH (EHE-LEACH) Protocol for Lifetime Enhancement of SNs	EHE-LEACH has better network lifetime than LEACH and SEP

V. CONCLUSIONS

It has been observed in literature review that Extended Heterogeneous LEACH protocol for wireless SNs the energy efficiency, extended life time and improved system stability make EHE-LEACH an attractive protocol for wireless SNs. In order to improve the stability of the network system and lifetime Observations show that EHE-LEACH has better lifetime and stability of the system as compared with LEACH and SEP for same energy level. We compared EHE-LEACH with LEACH and other all protocol techniques mention in literature review table but due to the presence of various clustering algorithms that we need to evaluate and in future other factors can have an effect on the network lifetime. For future work, a model with heterogeneous wireless sensor nodes with its topology to have good energy efficient and increasing lifetime network may be investigated in different future requirements.

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